Appendix 2 Summary of Statewide Ground-Water-Level Monitoring and Sampling Programs in the United States, 2007

Additional details on the status of ground-water monitoring activities in the United States are provided in this appendix. Sections A2-1 and A2-2 present a state-by-state summary of the total number of wells for which ground-water level measurements are made and ground-water quality measurements were collected by the USGS or cooperators, stored in the USGS database, and made available on the Internet. Sections A2-3 and A2-4 present a summary of the water level and water-quality results from the State/Regional Ground Water Monitoring Networks Report (Association of American State Geologists, the Ground Water Protection Council, the Interstate Council on Water Policy, and the National Ground Water Association, 2007). Section A2-5 provides the initial report from the Association of American State Geologists, the Ground Water Protection Council, the Interstate Council on Water Policy, and the National Ground Water Association including the survey questions.

A2-1 Water-Level Data Collected by USGS and Cooperators in 2008

The U.S. Geological Survey (USGS) monitors ground-water levels primarily through agreements with State and local cooperators under the USGS Cooperative Water Program, and secondarily through Federal programs like the Ground-Water Resources Program and the National Water Quality Assessment Program. Water levels from about 800,000 wells are stored in the USGS database. Wells with water levels measured in 2008 by the USGS and Cooperators are shown in figure A2-1.1, and listed by state in table A2-1.1.

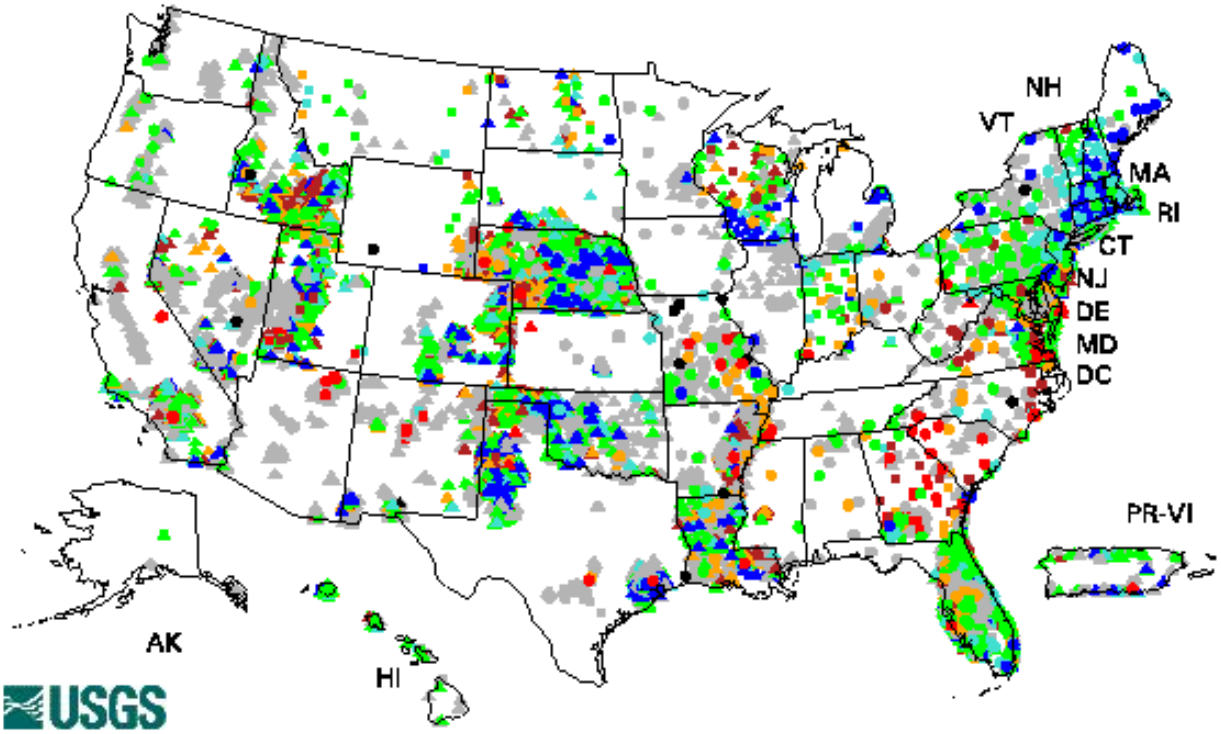

Figure A2-1.1: Wells with water levels measured in 2008 by the USGS and Cooperators.

Table A2-1.1: Wells with water levels measured in 2008 by the USGS and Cooperators, enetered into the National Water Information System database, and made available on the Internet.

State	Total wells	Total wells with at least 5 years of measurements	Wells measured once per year	Wells measured four times per year	Wells measured monthly	Wells measured daily	Real Time Wells
AK	15	15	2	10	0	3	1
AL	27	4	17	0	0	10	10
AR	751	343	673	36	4	20	19
AZ	279	141	102	35	0	49	15
CA	2,151	1,344	1,270	354	54	182	90
CO	1,046	871	656	126	67	1	1
CT	75	74	59	2	0	4	4
DC	31	25	1	22	0	5	0
DE	39	31	34	4	0	1	1
FL	1,595	462	2	0	0	524	205
GA	665	231	450	19	0	190	29
HI	60	13	0	1	0	15	4
IA	15	6	7	1	2	5	5
ID	1,734	746	418	405	16	16	4
IL	89	21	74	7	0	3	1
IN	213	130	88	1	0	34	6
KS	399	378	2	337	0	32	24
KY	65	53	2	33	0	30	1
LA	383	303	82	264	0	9	9
MA	178	147	114	8	16	16	14
MD	613	525	345	51	81	10	9
ME	25	19	0	0	0	25	24
MI	184	122	80	30	0	40	2
MN	102	11	69	0	0	32	23
MO	166	85	26	0	0	138	138
MS	53	36	22	9	9	5	4
MT	44	42	3	18	4	17	2
NC	201	175	55	45	30	68	64
ND	53	52	6	40	0	3	3
NE	4,373	4,071	3,436	43	51	44	24
NH	26	26	24	0	0	2	2
NJ	300	162	37	19	0	184	20
NM	991	522	495	178	12	97	0
NV	651	541	329	185	6	11	11
NY	711	75	13	8	1	123	74
OH	107	55	54	33	0	20	12
OK	489	123	482	0	0	7	7
OR	220	188	62	82	0	17	4
PA	197	137	78	9	31	77	69
PR	136	52	44	16	16	54	2
RI	38	36	19	0	11	6	5
SC	85	16	33	1	0	21	21
SD	139	134	120	3	1	12	12
TN	89	69	43	7	0	35	22
TX	2,868	2,194	2,647	8	17	36	24
UT	849	680	752	27	0	39	1

VA	450	341	41	287	0	99	81
VT	13	13	13	0	0	0	0
WA	426	304	96	147	98	1	1
WI	157	95	88	22	11	33	3
WV	30	7	18	0	0	12	12
WY	66	61	21	0	0	44	2
Total	24,662	16,307	13,604	2,933	538	2,461	1,121

A2-2 Water-Quality Data Collected by USGS and Cooperators in 2006-2007

The U.S. Geological Survey (USGS) monitors ground-water quality primarily through agreements with State and local cooperators under the USGS Cooperative Water Program and the USGS National Water-Quality Assessment Program. Table A2-2.1 lists wells and springs with water-quality samples analyzed in Water Year 2006 (2006-2007) by the USGS and Cooperators, by state.

Table A2-2.1: Wells and Springs with water-quality samples analyzed in 2006-2007 by the USGS and Cooperators, entered into the National Water Information System database, and made available on the Internet.

	Ground water		Spring	
	Wells Sampled	Continuous Monitors	Sampled	Continuous Monitors
Alabama	16	0		
Alaska	0	1		
Arizona	79	0	34	0
Arkansas	82	11	1	10
California	833	3	24	3
Colorado	75	2	1	0
Florida	408	9	17	7
Georgia	21	0		
Hawaii	7	0	12	0
Idaho	612	0	3	0
Illinois	2	0		
Indiana	20	0	9	0
Iowa	160	10	1	0
Kansas	191	18		
Kentucky	1	10	5	2
Louisiana	109	5		
Maryland+Delaware+DC	78	6		
Michigan	2	0		
Minnesota	102	28		
Miss	57	11		
Missouri	64	0	12	2
Montana	14	0	23	0
N.Carolina	51	3		

N.Dakota	60	0		
Nebraska	124	23		
Nevada	89	4	31	0
New England	380	16		
New Mexico	156	3	8	0
New_Jersey	91	0	1	0
New_York	285	45	2	0
Ohio	29	0		
Oklahoma	15	0	1	0
Oregon	27	9	1	0
P_Rico	0	0		
Penn	245	0	10	0
S.Carolina	62	1		
S.Dakota	75	0	2	0
Tennessee	13	1	5	0
Texas	173	4	19	3
Utah	169	0	10	0
Virginia	18	0		
W.Virginia	35	0		0
Wash	76	0		
Wisconsin	120	0		
Wyoming	11	0	1	0
Total	5237	223	233	27

A2-3 Summary of Water-Level Information in the State/Regional Ground Water Monitoring Networks Report

PROGRAM MANAGEMENT

The ground-water networks are intended to provide specific management information, and the top six management issues identified were:

- trends in ground-water levels over time 40 of 40
- current unstressed ground-water condition 38 of 40
- how do ground-water levels change over time? 32 of 40
- effects of drought and climate change 29 of 40
- effects of over pumping of aquifers 27 of 40
- effectiveness of ground-water management programs 19 of 40

The existing networks could be used to answer the following issues. The top 6 of 10 responses are shown below. Note that the issues are the same identified above but are arranged in a different order.

- current unstressed ground-water condition 7 of 40
- trends in ground-water level over time 6 of 40
- effects of drought and climate change 5 of 40
- how do ground-water levels change over time? 5 of 40
- effects of over pumping of aquifers 9 of 41
- effectiveness of ground-water management programs 7 of 41

The 40 respondees identified 11 State/Regional and Federal agencies that either manage or share management responsibilities with other agencies. Eight State agencies and three Federal agencies are involved, with the USGS participating in many of the management groups. The USGS involvement probably is substantial because they partner with many State, County, and local agencies through the USGS Cooperative Water Program (CWP).

- U.S. Geological Survey 13 of 40
- State Geological Survey 10 of 40
- Department of Natural Resources 8 of 40
- Department of Water Resources 6 of 40
- Department of Environmental Protection/Environmental Quality 4 of 40
- State Engineers Office 4 of 40
- Regional Government Agency 3 of 41
- State Dept. of Agriculture 2 of 41
- Others (Department of Environment and Natural Resources, Natural Resource Conservation Service, Texas Water Conservation Board 3 of 40

State/Regional ground-water-level networks are funded primarily by State, County and local agencies. The 40 responses indicated funding as follows:

- mostly State, County, and local (27 states) 29 of 40
- about 50/50 Federal/State, County, and local 7 of 40
- other (mixtures of Federal/State, County, and local) 8 of 40
- mostly Federal funds 2 of 40

The responses indicate that over half (at least 22) of the responding agencies have Cooperative Programs with the USGS for ground-water-level monitoring activities. Fourteen indicate that the USGS participates in the management of water-level monitoring. Two State/Regional efforts are mostly supported by Federal funds, and seven have approximately 50 percent support.

PROGRAM DESIGN

Network designs are based mainly on aquifers, political subdivisions, and physiography or some combination of the three. Twenty-two States/Regions use a single criterion—16 are based on aquifers, 2 on political subdivisions, 1 on watersheds, 1 on climate response, 1 on soil types, and 1 on particular units in the State. Twenty-two States use multiple criteria. Table A2.3.1 illustrates the variety of considerations used to design the networks of these 19 States.

Table A2.3.1 Multiple Criteria Used for Network Design by States/Regions.

Criteria used	State/Region
Aquifer-physiography	Minnesota, Massachusetts
Aquifer-watershed	Florida Colorado, New Jersey, Indiana
Aquifer-political subdivision	Virginia, Wisconsin
Aquifer-watershed-physiography	New York, Massachusetts,

	Washington
Aquifer-political subdivision-pumpage	Texas
Aquifer-watershed-physiography-political subdivision	Delaware, California
Physiography-designated ground-water basin	Arizona
Physiography-watershed-political subdivision	New York
Other	Wyoming, Oregon, Rhode Island

Wells and other observation points are used for determining ground-water levels. Dedicated monitoring wells are used by 38 of the 40 networks to measure ground-water levels (fig. A2-3.1). Ten States use dedicated monitoring wells exclusively (Delaware, Florida, Indiana, Massachusetts, Missouri, Nebraska, New Jersey, New York, Rhode Island, and South Carolina). It is likely that most of the wells are ones inherited rather than drilled specifically for water-level measurements. Also non-well observation points are used in addition to wells, for example, stream base-flow measurements and springs. The agencies operating the networks are very inventive in assembling various combinations of wells and observation points for their networks as 24 combinations were reported. The combinations vary from two to six combinations of wells and observation points per network, with the most "popular" being the combination of dedicated-domestic-irrigation-public water-supply wells that is used by Georgia, Louisiana, Mississippi, and Wyoming. Oklahoma and Texas do not use any dedicated ground-water-level monitoring wells.

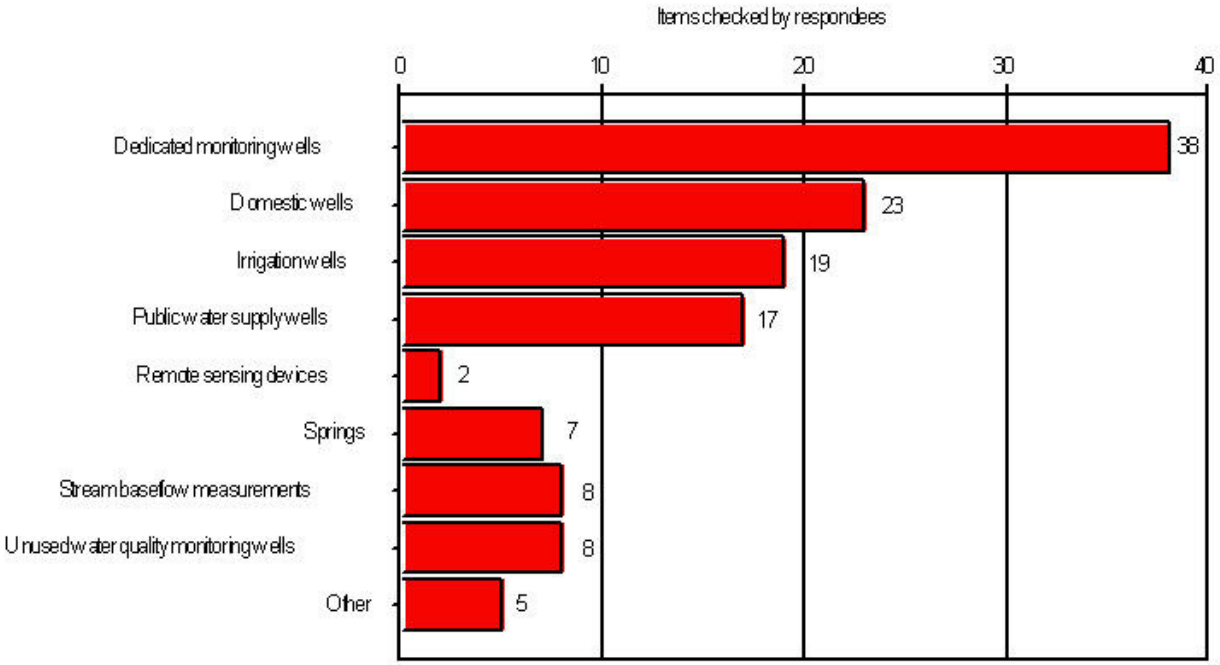

Figure A2-3.1 – Ground-water level observation points used by statewide/regional networks.

WATER-LEVEL MEASUREMENT FREQUENCIES

Respondees from 40 States and the USGS reported data on 44 networks about the frequencies that ground-water levels are measured (Appendix 2A). The responses include both statewide and regional networks. The data summarized include two State networks in Delaware and both Statewide and Regional networks in Florida and Ohio. Also included are five States—

Connecticut, Indiana, Iowa, Pennsylvania, and Utah—in which the USGS manages and operates Statewide networks. States reporting neither a Statewide nor a Regional network, however, may have a significant number of ground-water-level wells operated by the USGS, including New Mexico (38 wells), Tennessee (115 wells), Kentucky (81 wells), Maine (38 wells), and Alaska (24 wells).

Frequency of measurement data was tabulated in the following categories: annual only, semiannual only, quarterly only, monthly only, weekly only, daily only, and real time. Some States focused on annual and semiannual measurements (e.g., Kansas, Maryland, Mississippi, Nebraska, Nevada, and Texas). Others preferred quarterly (Louisiana, Montana, North Carolina, and Virginia) or monthly (Massachusetts, North Dakota, and South Dakota) measurements. Daily and real time are a focus of Florida-R, New Jersey, Ohio-S and Wyoming. Figure A2-3.2 illustrates the frequency distribution for Nevada that strongly emphasizes annual measurements. The wells in most networks have a minimum of 5 years of data.

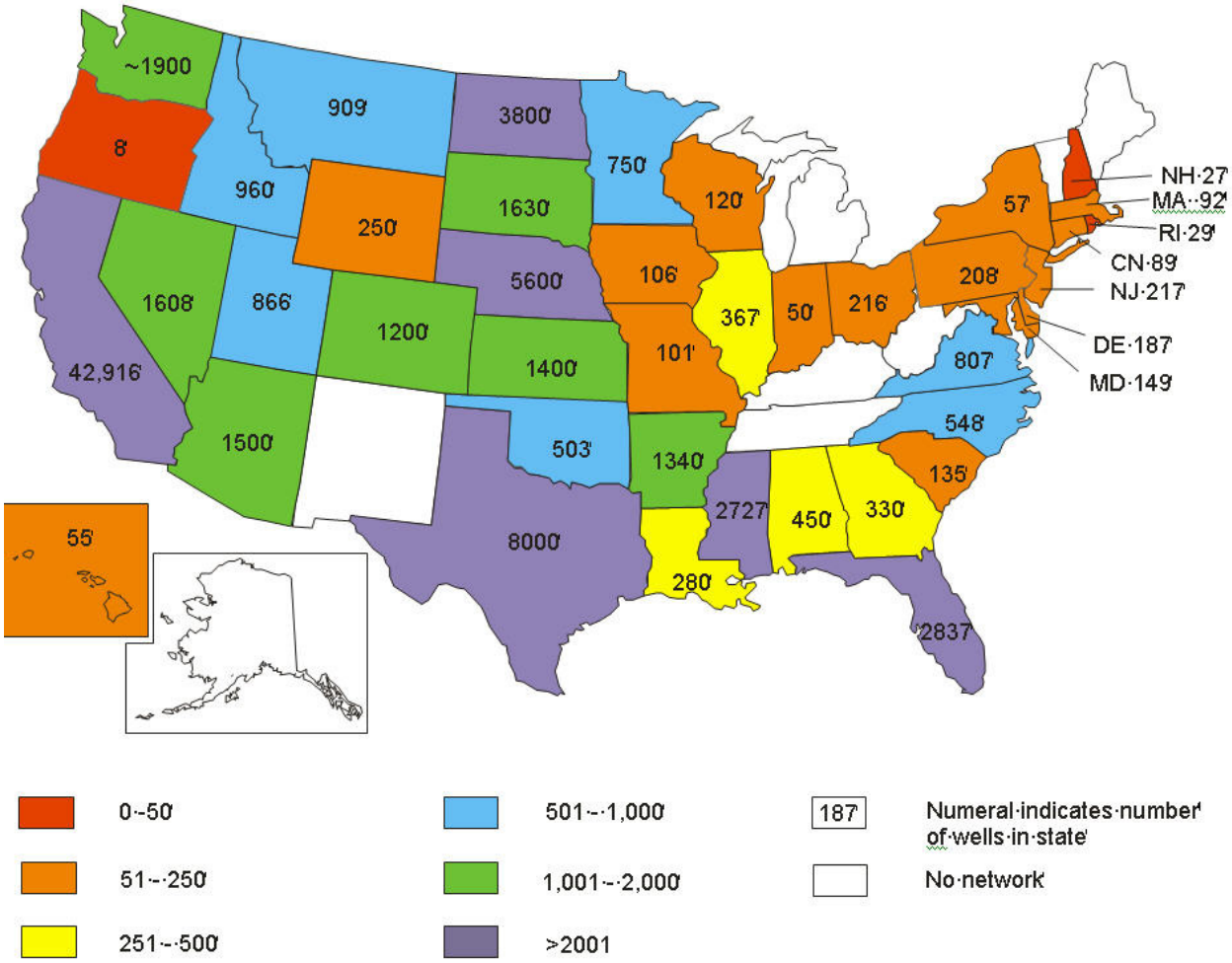

Figure A2-3.2 – Number of wells in statewide and/or regional networks measured at least annually.

Of the 44 networks reporting, the primary frequency that is used varies from 5 years to real time (table A2-3.2). Twelve networks used one sampling frequency 90 percent or more of the time, and 39 networks favored using one frequency 50 percent or more of the time. The focus

on a particular frequency measurement cycle probably depends on the objective of the specific network and staffing requirements.

Table A2-3.2. Ground-Water-Level Measurement Frequencies.

Primary Frequency Measured	Number of Networks	Network
5 years	2	Florida, Illinois
Annual	14	Alabama, Arizona, Arkansas, Colorado, Idaho, Indiana, Iowa, Kansas, Mississippi, Nebraska, Nevada, Oklahoma, Texas, Utah
Semiannual	3	Maryland, Washington, Wisconsin
Quarterly	10	Connecticut, Delaware, Delaware, Hawaii, Louisiana, Montana, North Carolina, Oregon, South Carolina, Virginia
Monthly	8	Massachusetts, Minnesota, New Hampshire, New York, North Dakota, Rhode Island, South Dakota, Ohio
Daily	5	Florida, Georgia, New Jersey, Ohio, Wyoming
Real Time	2	Missouri, Pennsylvania

Ground-water-level information for the State and Regional networks is collected primarily by State employees, USGS staff, and regional/local employees (fig. A2-3.3). As might be expected, the bulk of the data is being collected by agencies who are managing/operating the networks. In two States (New Hampshire and Wisconsin), volunteers also participate.

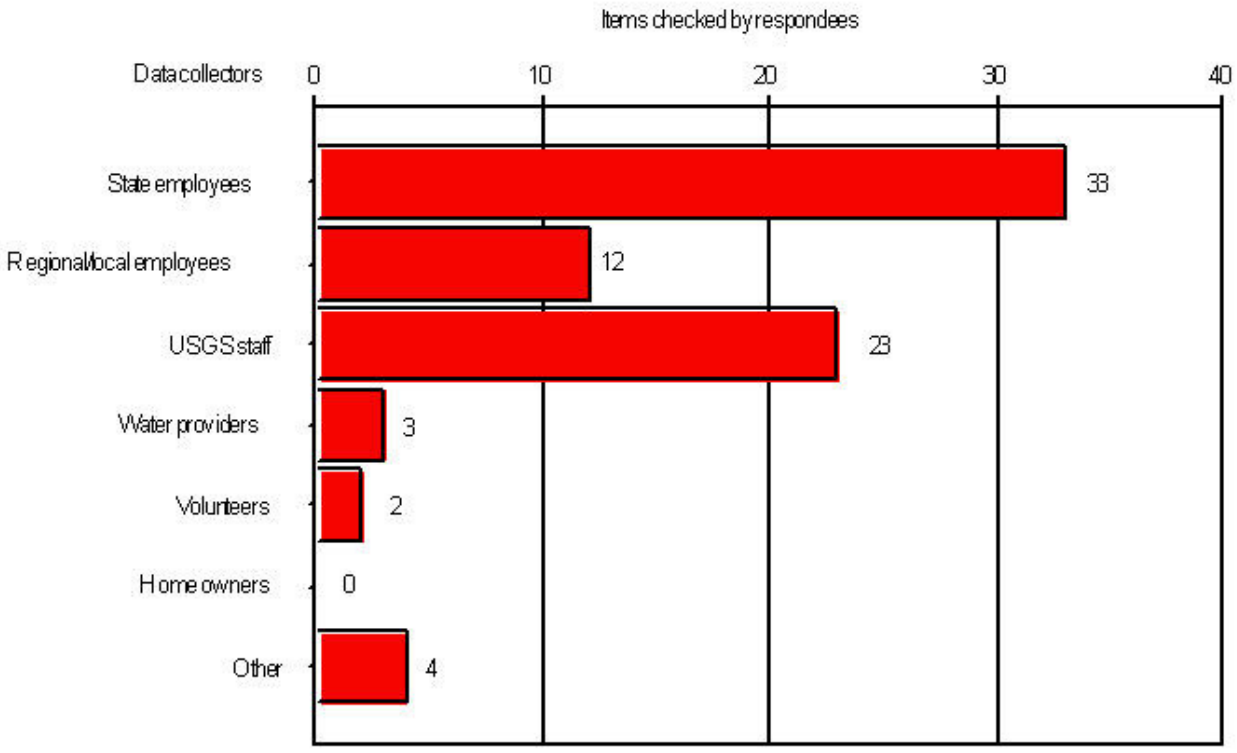

Figure A2-3.3 – Collectors of ground-water level data for state and regional networks (41 respondees).

DATA AVAILABILITY

Twenty-three of 34 information items that generally are available for wells and observation points are considered important by half (21 or more) of the respondees (fig. A2-3.4). Most of the respondees (35 of 40) consider the following information to be necessary: well number, county code, lat/long, land-surface elevation, date drilled, well depth, water-level available, and casing diameter. Items of potential interest with less than 20 respondees include land use in the area (4), weather/climate at time of measurement (2), primary water use (20), and water quality available.

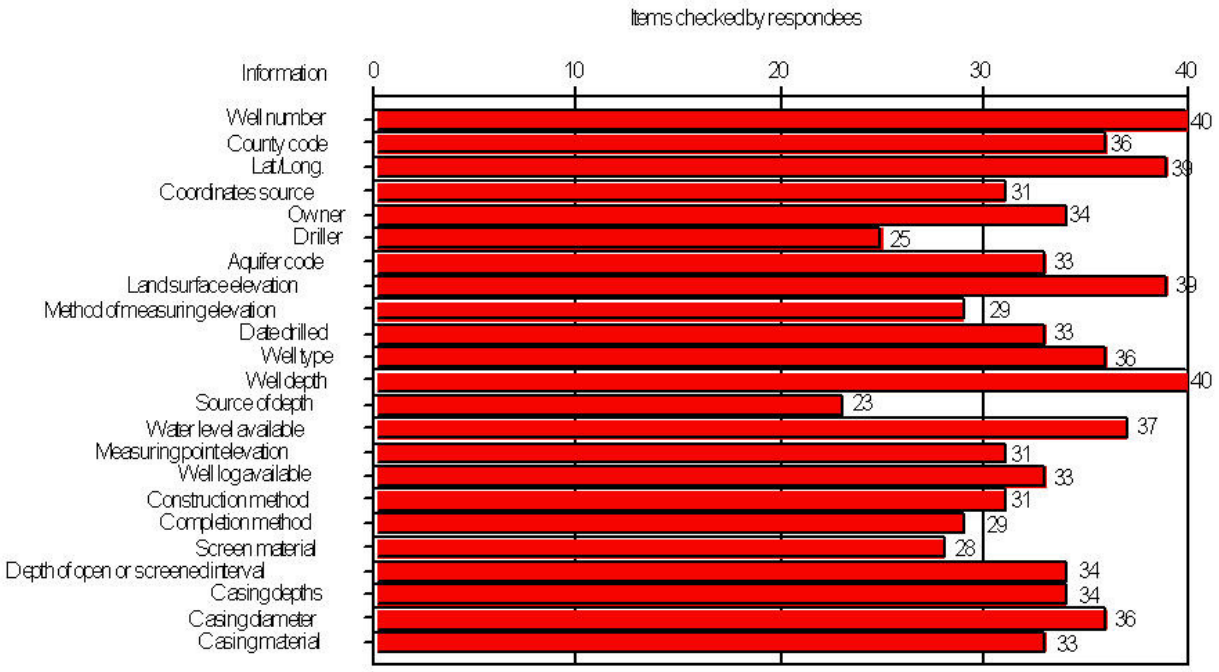

Figure A2-3.4 – Information available for wells or observation points (41 respondees).

Standard operating procedures (SOPs) used for Field Data Collection and Data Management and Storage are critical to securing comparable data; however, the lack of written SOPs was substantial for both activities—8 of 40 (in 8 states) for Field Data Collection (fig. A2-3.5) and 12 of 41(12 states) for Data Management and Storage (fig. A2-3.6). USGS and State agencies were the primary agencies that developed the SOPs, 38 of 40 (in 35 states) for Field Data and 29 of 40 (in 27 states) for Data Management and Storage. Of particular interest is the almost complete underdevelopment of SOPs by State, regional or local agencies for Field Data (0 of 40) and Data Management and Storage (1 of 41. Two States show under development at state level (Washington and Wyoming).

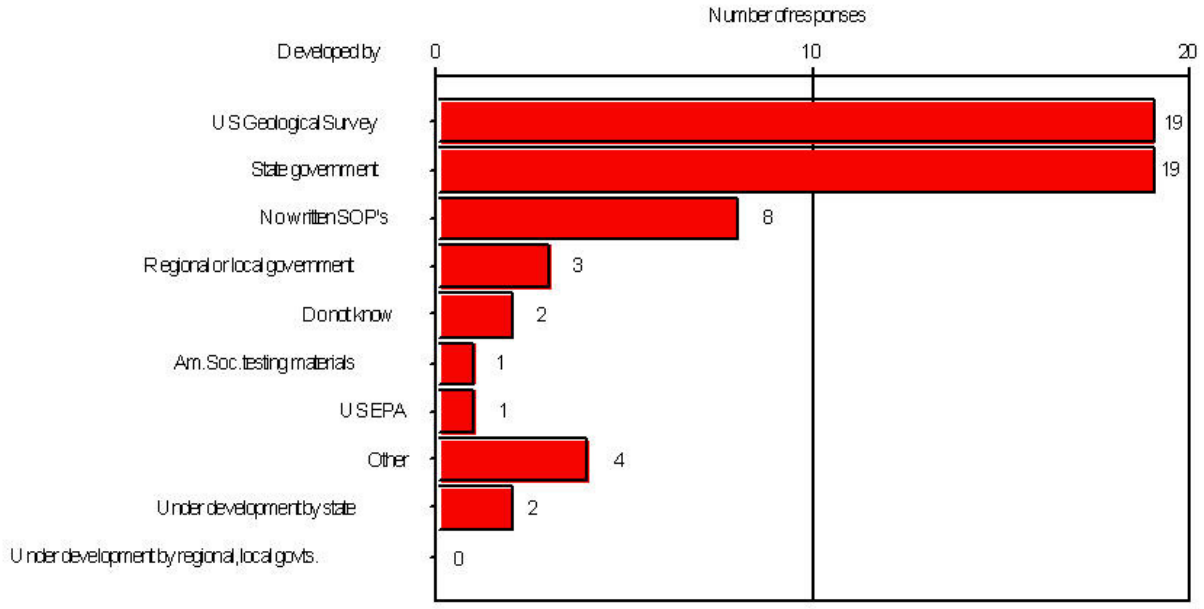

Figure A2-3.5 – Who developed standard operating procedures for field data collection (41 respondees)?

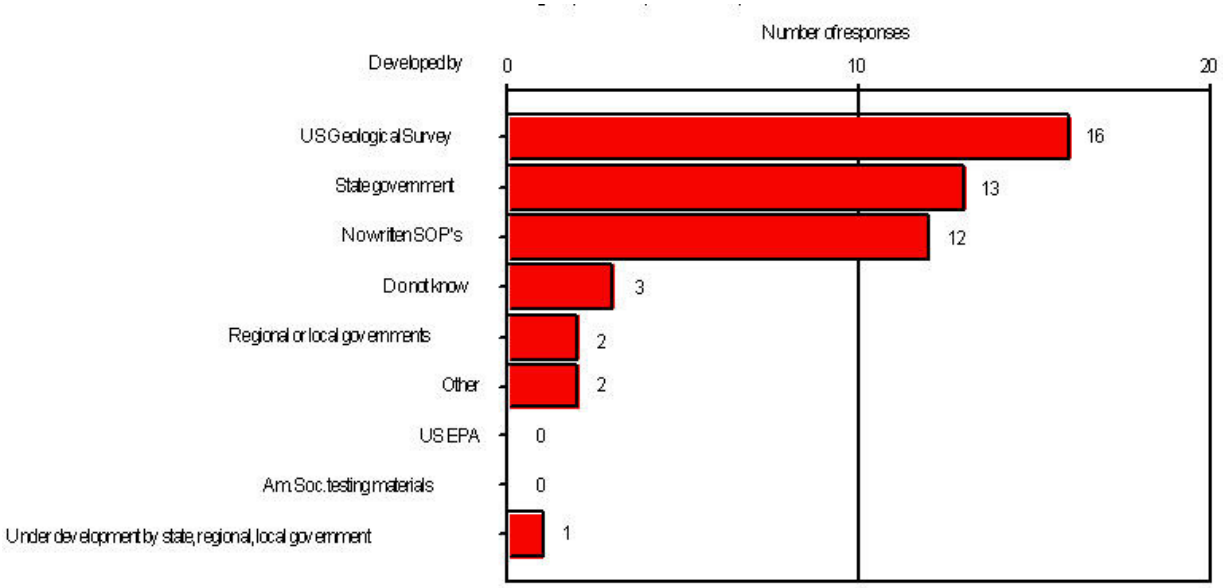

Figure A2-3.6 – Who developed standard operating procedures for data management and storage (41 respondees)?

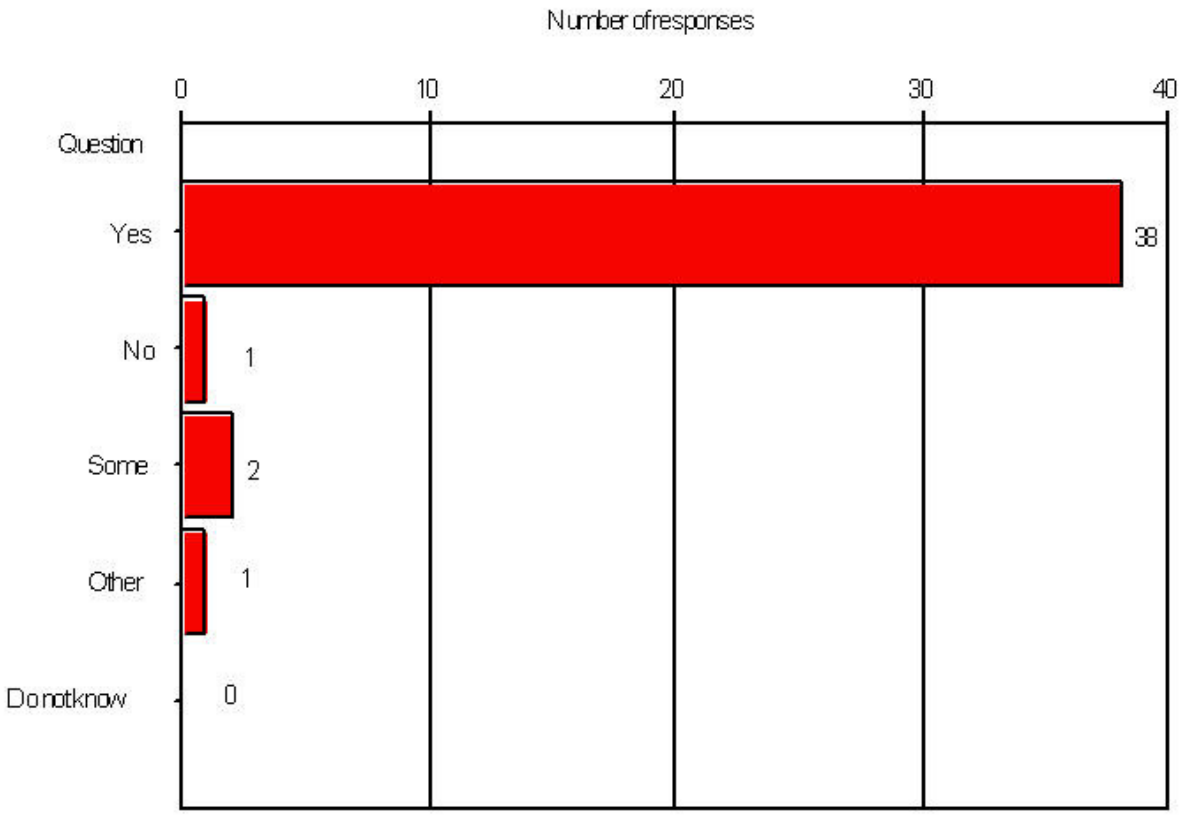

Figure A2-3.7 – Data collected, enterend, and maintained in a computer database (41 respondees).

A key issue concerns storage of water-level data in a database (fig. A2-3.7) and the availability of those data to the public. Thirty-six States entered and maintained some or all of the data for one or more statewide and/or regional ground-water-level monitoring networks in a computer database. Thirty-eight of 40 respondees entered and maintained their data in a computer database (fig. A2-3.7), and only 1 State did not. Thirty-six of 40 respondees made all or some of the data available on a website (fig. A2-3.8), and only 3 of 40 did not do so.

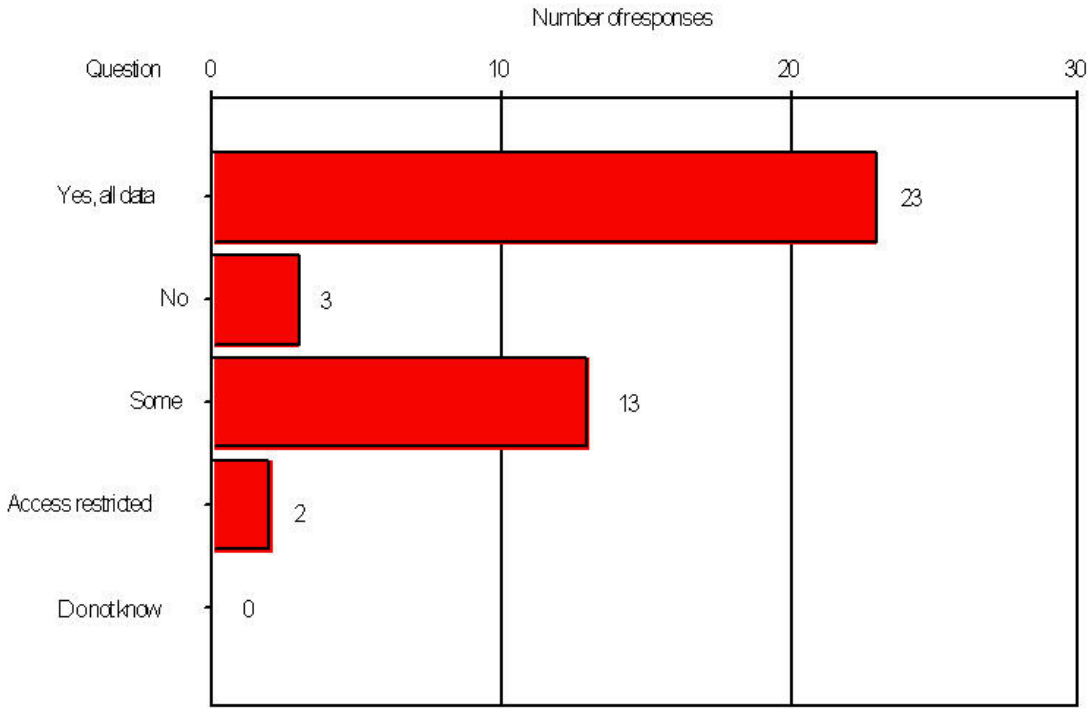

Figure A2-3.8 –Web accessibility of data to the public (41 respondees).

A2-4 Summary of Water-Quality Information in the State/Regional Ground Water Monitoring Networks Report

Program management - In 11 of the 33 States that have active ground-water-quality sampling programs, the State Department of Environmental Quality or State Environmental Protection Agency manages the program (fig. A2.4.1). The State Geological Survey is the sole program manager in three States (Iowa, Maryland, South Dakota) and program management is shared in four other States (Delaware, Montana, Nebraska, New Jersey). In 11 States, program management is split between two or more agencies (State Departments of Environmental Quality, USGS, State Departments of Agriculture, State Geological Surveys). In Hawaii, the statewide ground-water-quality monitoring program is managed by the State Health Department. In Connecticut, the USGS is the sole manager of the statewide program. In four other States (Illinois, Louisiana, Michigan, Utah), the USGS is a cooperating agency. In six states with active programs, other agencies manage the program(s). The State Department of Agriculture manages regional ground-water-quality sampling programs in five states (Delaware, Idaho, Illinois, Montana, Pennsylvania) and statewide programs in three States (Colorado, Nevada, Tennessee).

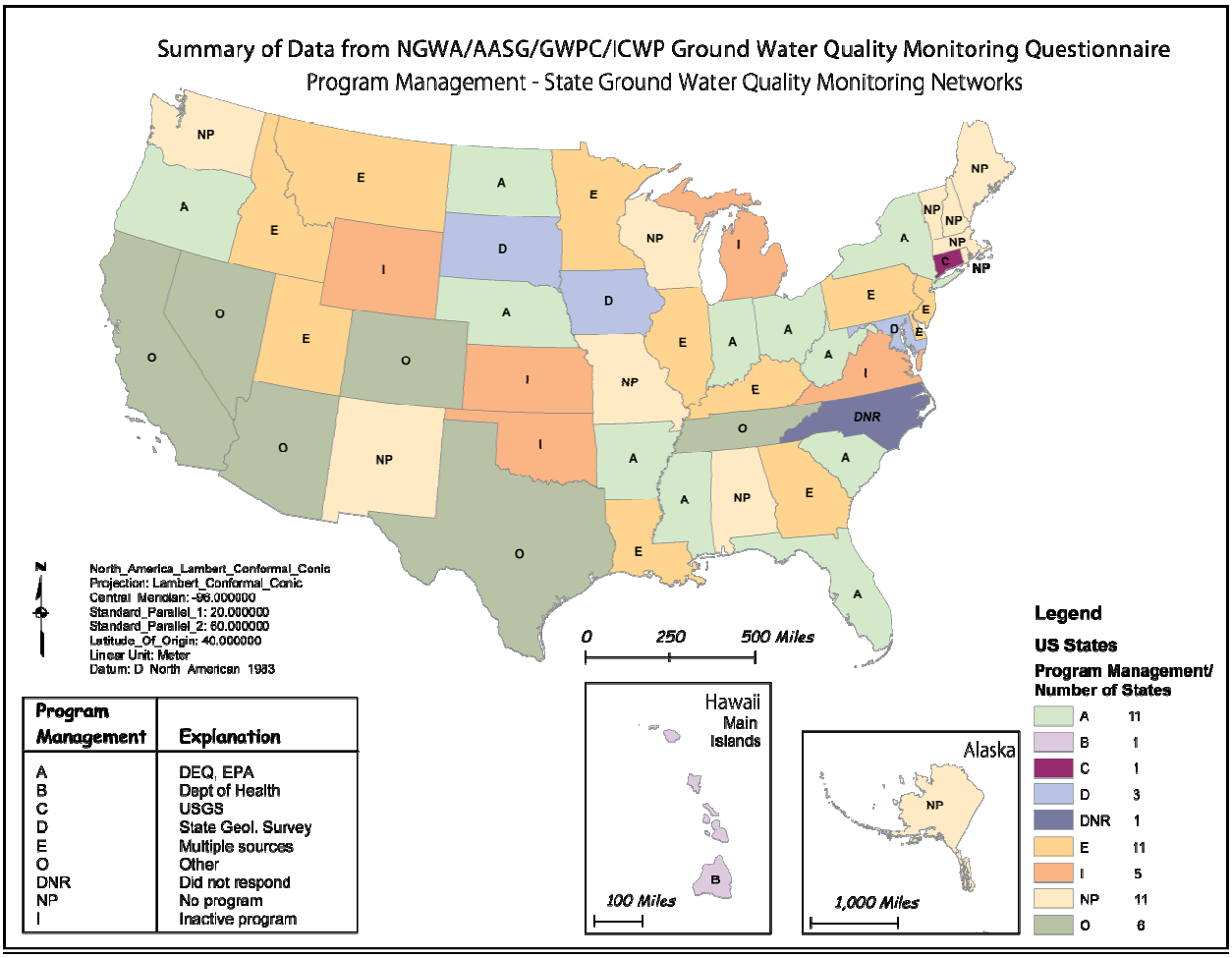

Figure A2.4.2

Program funding – Funding sources for managing State ground-water-quality monitoring programs include Federal (USGS or U.S. Environmental Protection Agency [USEPA]), State, and local government funds (fig. A2.4.3). Twelve States rely solely on Federal funding, and five States rely solely on State funding. Twelve States reported that funding was split between Federal and State funds. Funding for the three other States that have active ground-water-quality monitoring programs is obtained from other sources.

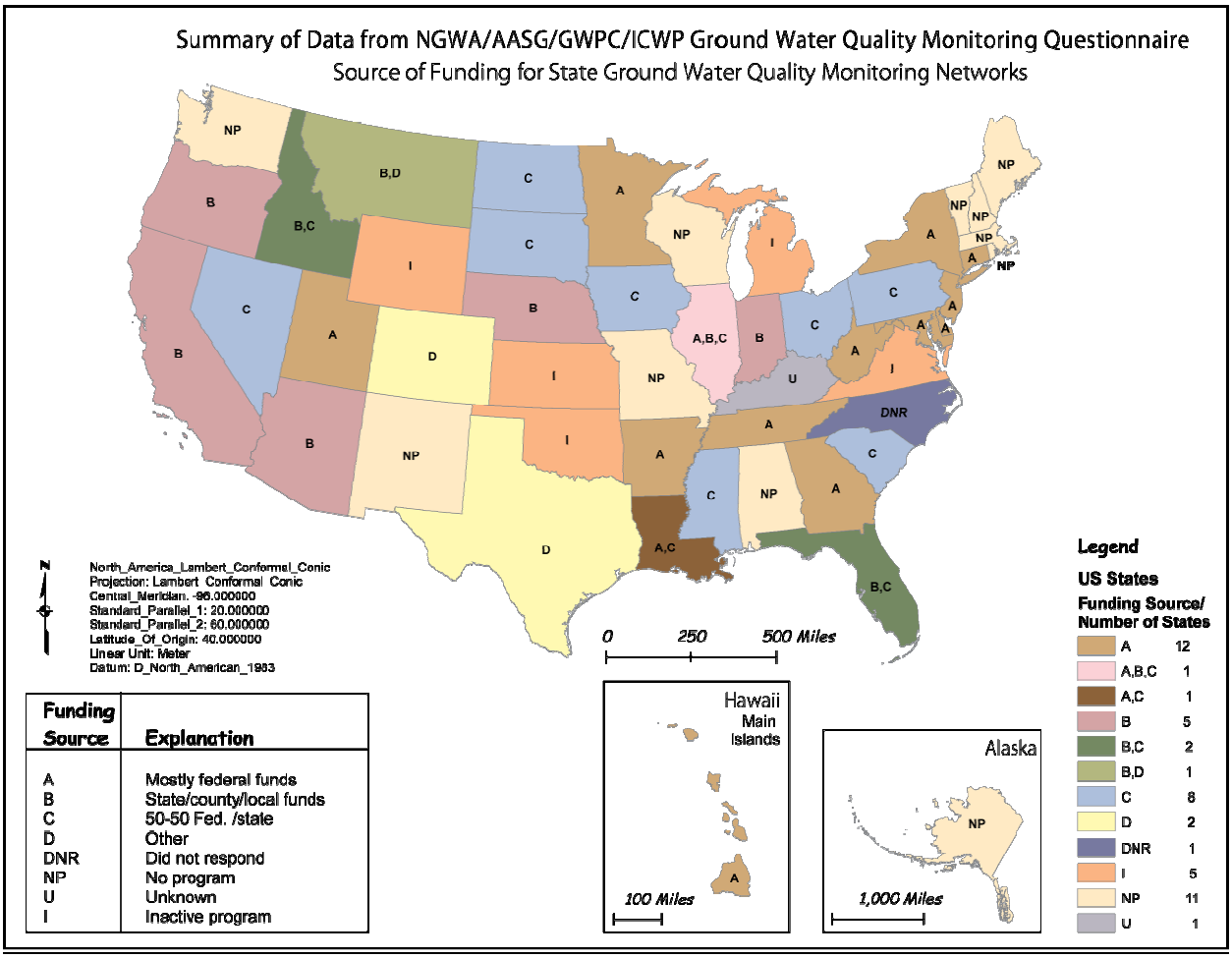

Figure A2.4.3

Program design basis – Monitoring locations, sampling schedules and analyte lists for specific ground-water-quality sampling programs are determined on the basis of the overall design and objectives of the program. In six States (Arkansas, Colorado, Iowa, Minnesota, North Dakota, South Dakota), the design of the ground-water-quality sampling program is based solely on aquifers (fig. A2.4.4). Eighteen other States based their design on aquifers and a combination of watersheds, geographic regions and political subdivisions. Two States utilize watershed boundaries when designing the ground-water-quality monitoring programs, 5 States considered political subdivisions, and 16 States considered geographic areas. It is apparent from figure A2.4.4 that there are a number of factors that influence program design; however, in most States, the sampling programs are designed primarily to focus on specific aquifers.

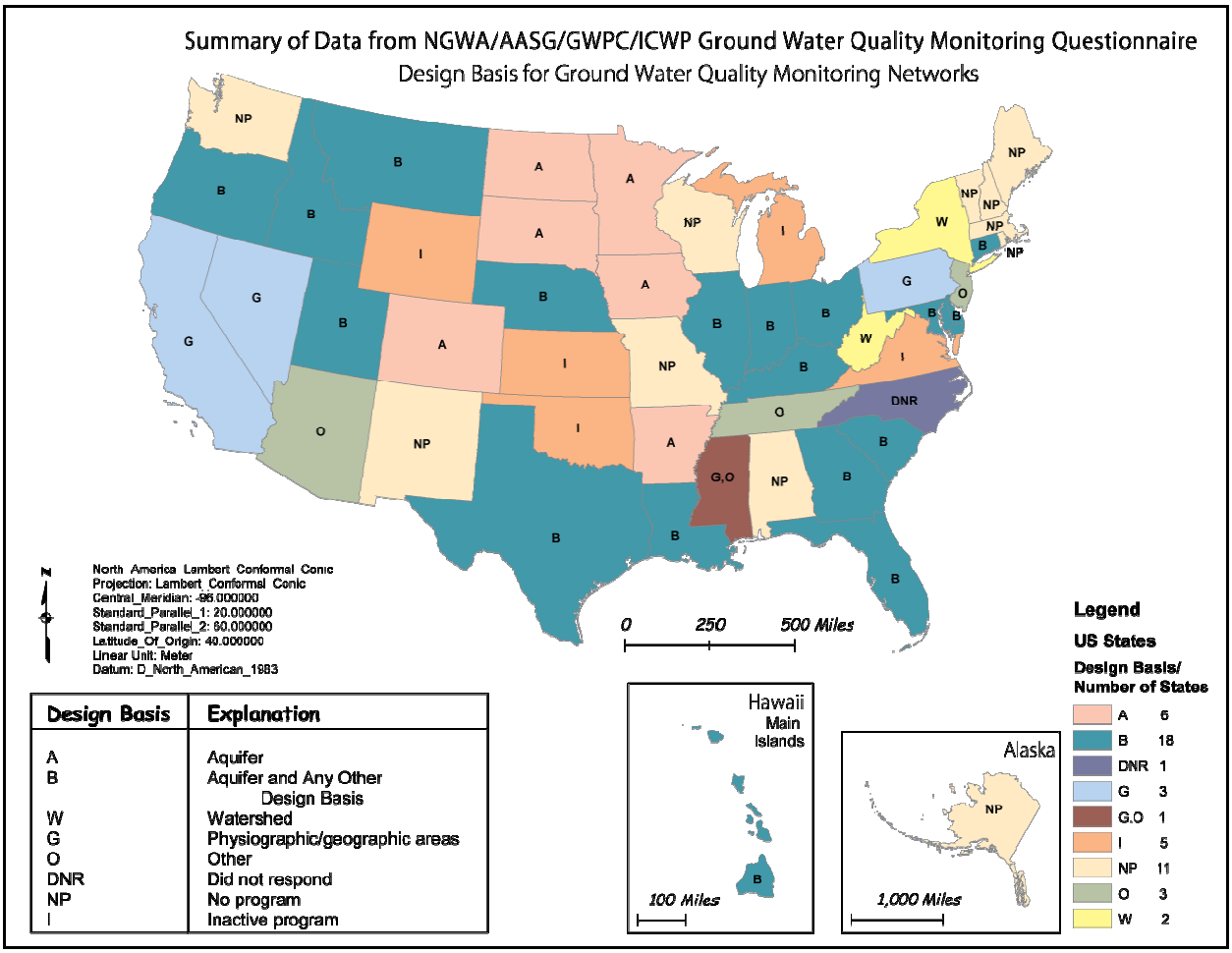

Figure A2.4.4

Type of observation points - The questionnaire included data on the types of wells and other observation points used for the State ground-water-quality sampling program(s). Types of sampling locations include domestic wells, irrigation wells, and public water-supply wells. The questionnaire also asked if dedicated water-quality monitoring wells were used; however, the questionnaire did not include a definition of "dedicated." This constrains the data on dedicated wells. Only 3 States indicated the use of only dedicated wells in the State sampling program (Nevada, New Jersey, South Dakota); however, 15 States indicated that some dedicated wells were used in the sampling program(s) along with other types of sampling locations. Fifteen States indicated that there were no dedicated wells in the State program(s).

Analytes –The questionnaire included data on seven groups of analytes that are included in State ground-water-quality sampling programs. The analyte groups include basic field parameters, cations/anions, nutrients, radionuclides, pesticides, trace metals, and organics. These are commonly used groups of analytes; however, any individual State may have a slightly different list of analytes for a given analyte group than other States. All 33 States with an active program indicated that basic field parameters were included in the program(s) (fig. A2.4.5). Thirty-one States include basic cations/anions, 29 States include nutrients, 25 States include pesticides, 21 States include trace metals, and 20 States include organics. These data indicate that the State

ground-water-quality sampling programs are sampling for a wide variety of constituents in ground water. The data do not indicate that all sampling locations in a State program are sampled every time for all analyte groups. It is quite common to stagger sampling locations and analyte sampling over a period of months or years. Samples for some analyte groups may only be collected periodically.

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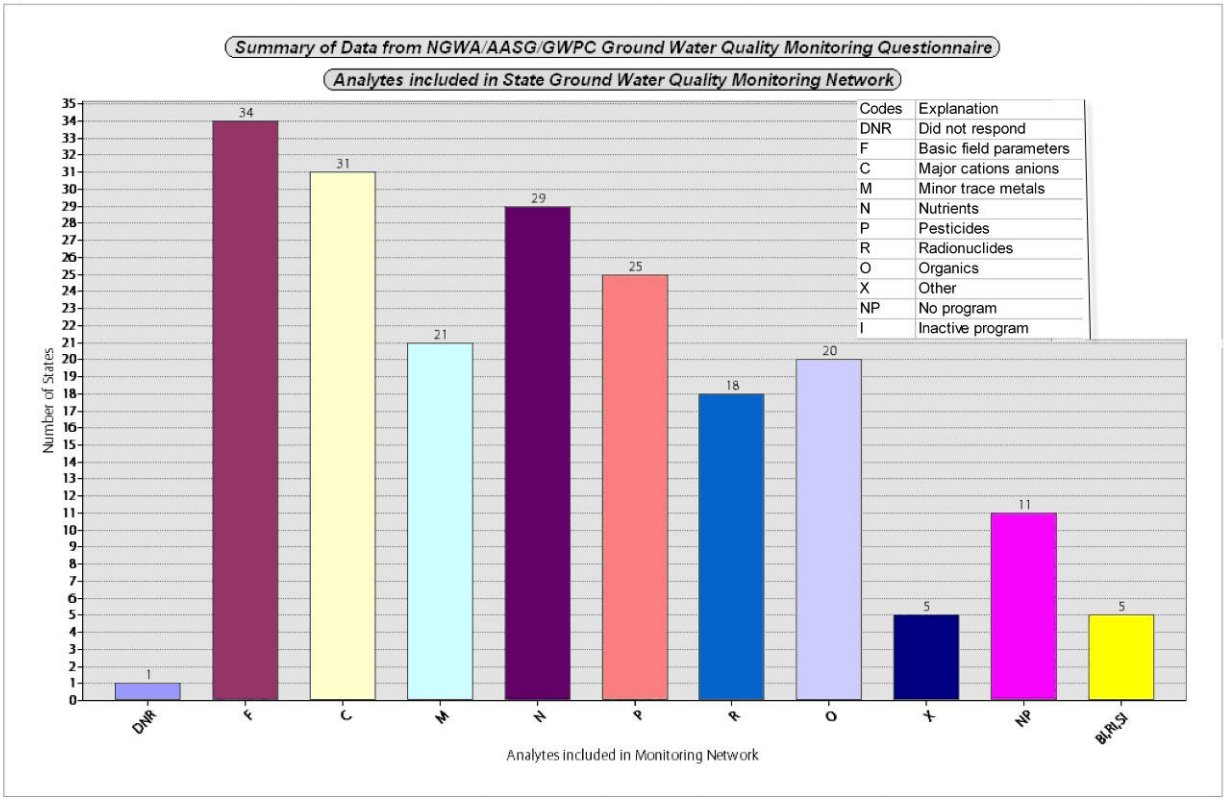

Figure A2.4.5

Program operation - In 20 of the 33 States that have active ground-water-quality sampling programs, the data are collected solely by State and local agency staff (fig. A2.4.6). The USGS is charged with collecting the ground-water-quality data in five States (Connecticut, New York, Pennsylvania, Utah, West Virginia). In eight States (Delaware, Idaho, Illinois, Iowa, Louisiana, Nebraska, New Jersey, Texas), the ground-water-quality data are collected jointly by the USGS and State agency staff.

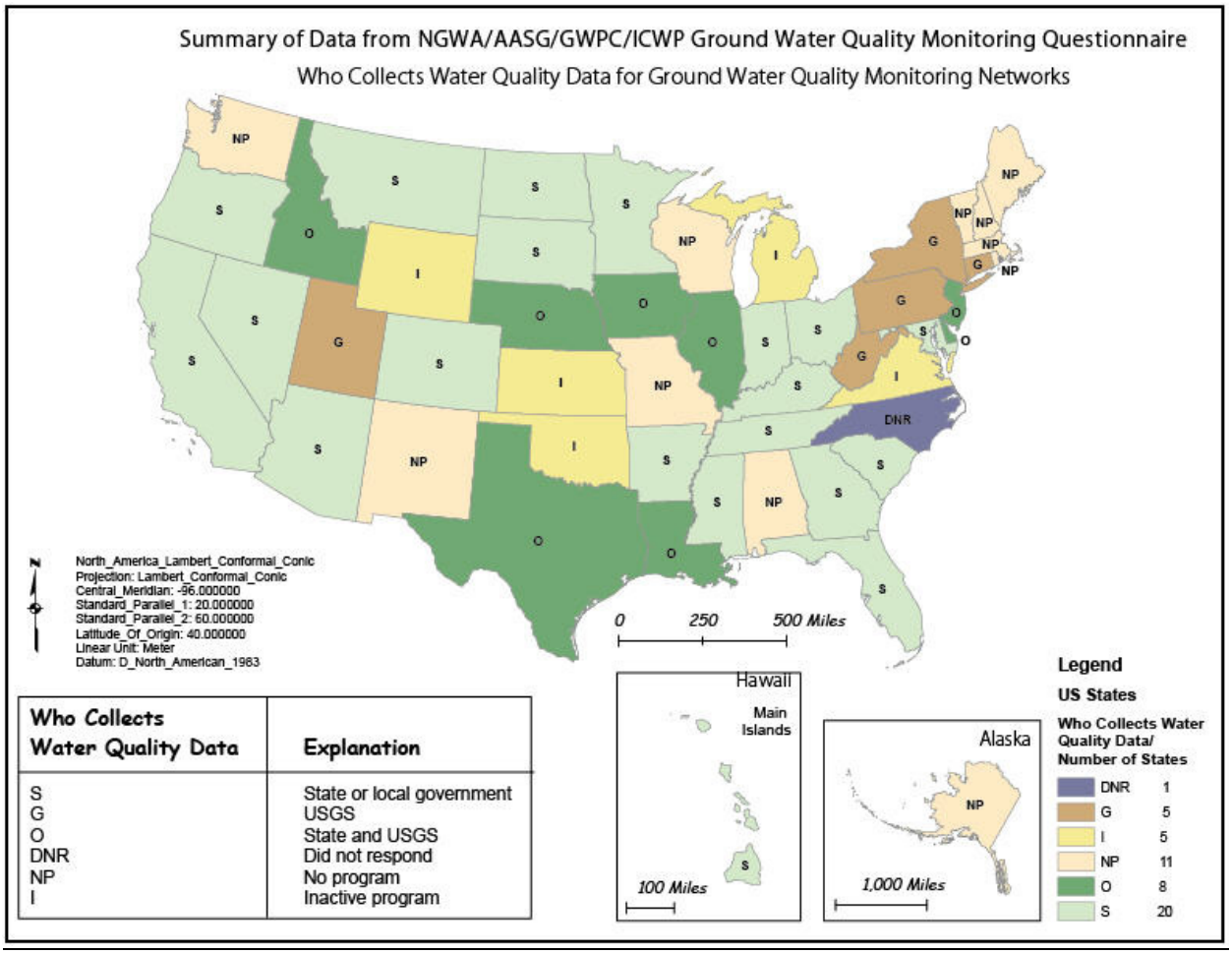

Figure A2.4.6

Who developed field-sampling SOPs? – Field-sampling SOPs that are used in State ground-water-quality sampling programs were developed primarily by the appropriate State agency (11 States), the USGS (4 States), the USEPA (1 State), or developed jointly by the USGS, the USEPA, and the appropriate State agency (12 States). Four States (Arkansas, Colorado, Hawaii, Illinois) reported that field-sampling SOPs are currently being developed.

Who developed data-management SOPs? – As with field-sampling SOPs, the 33 States with active programs are using data-management SOPs developed by a State agency, the USGS, or the USEPA. Eleven of the 33 States use SOPs developed solely by the State, 5 States use SOPs developed solely by the USGS, 11 States use SOPs developed by both the State and the USGS or the USEPA. Three States (Arkansas, Hawaii, Illinois) reported that data-management SOPs are being developed. One State (California) reported that there are no SOPs for data management. Two States (Pennsylvania, Tennessee) reported that they have data-management SOPs, but it is unknown who developed the SOPs.

Are data from ground-water-quality monitoring program available on a website?–The questionnaire included information on which States make the ground-water-quality data available on a website. Twelve States reported that all data are posted on a website (fig. A2.4.7).

Eight States (Arizona, Arkansas, Georgia, Hawaii, Mississippi, Nevada, North Dakota, Tennessee) reported that no data are posted on a website. Four States (Colorado, Iowa, Maryland, Ohio) reported that some but not all data are posted on a website. Two States (California, Illinois) reported that data are posted on a website, but access to the website is limited.

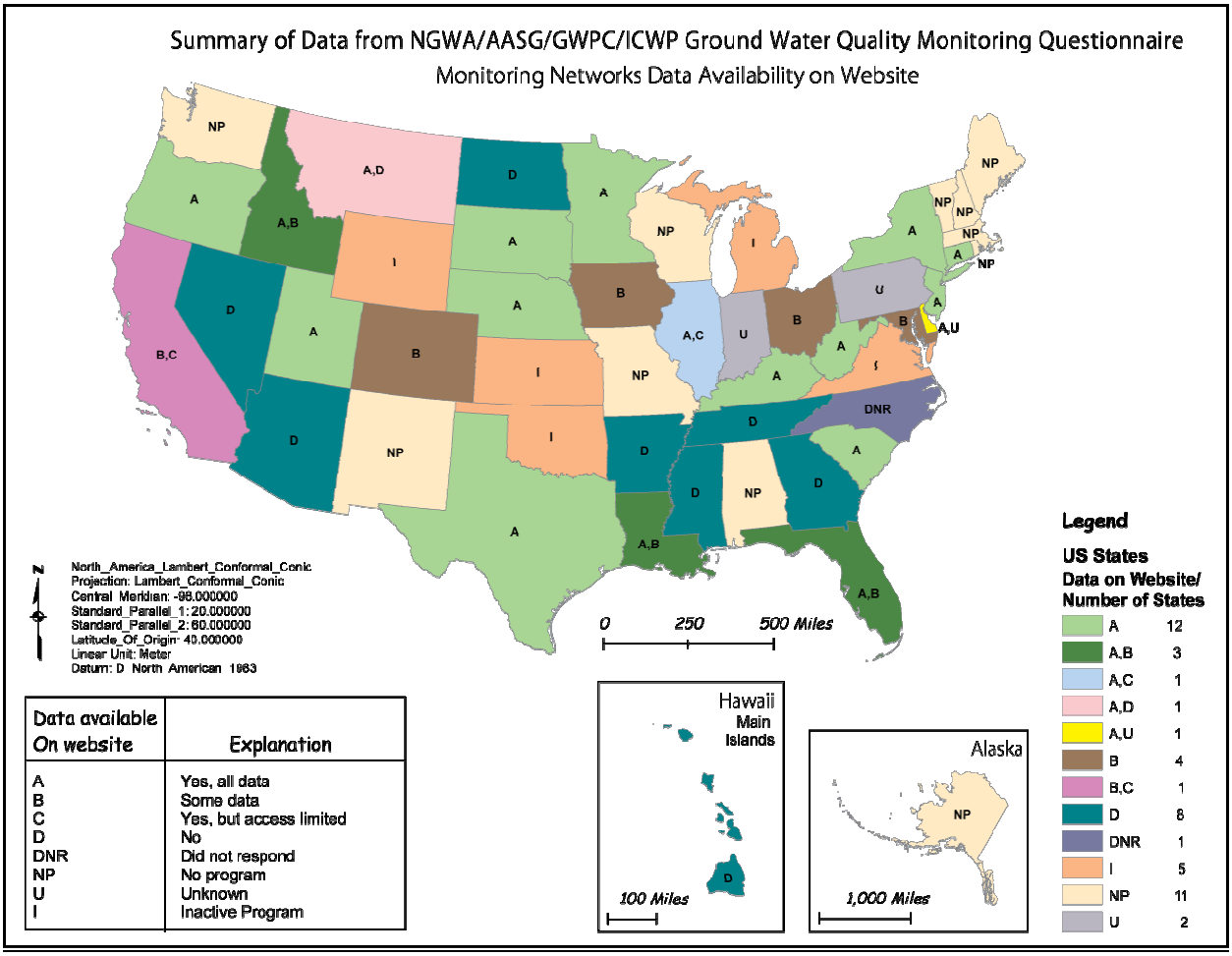

Figure A2.4.7

<u>Sampling frequency –</u>

States with more than 5 years of data for their program
- Annually – 19 states
- Semiannually – 14 states
- Quarterly -8 states

States with less than 5 years of data for their program
- Less than annually – 18
- Annually – 23 states
- Semiannually – 16 states
- Quarterly -14 states

A2-5 State/Regional Ground Water Monitoring Networks Report

This report is available in a separate document on the SOGW Web pages: http://acwi.gov/sogw/pubs/tr/index.html.